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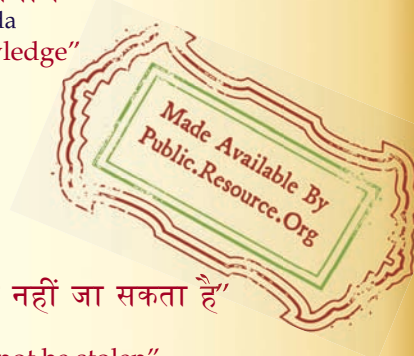
IS 6103 (1971): Method of test for specific resistance (resistivity) of electrical insulating liquids [ETD 3: Fluids for Electrotechnical Applications]



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*Indian Standard*

METHOD OF TEST FOR  
SPECIFIC RESISTANCE ( RESISTIVITY ) OF  
ELECTRICAL INSULATING LIQUIDS

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**BUREAU OF INDIAN STANDARDS**

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

NEW DELHI 110002

# Indian Standard

## METHOD OF TEST FOR SPECIFIC RESISTANCE ( RESISTIVITY ) OF ELECTRICAL INSULATING LIQUIDS

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# *Indian Standard*

## METHOD OF TEST FOR SPECIFIC RESISTANCE ( RESISTIVITY ) OF ELECTRICAL INSULATING LIQUIDS

### 0. FOREWORD

**0.1** This Indian Standard was adopted by the Indian Standards Institution on 28 December 1971, after the draft finalized by the Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

**0.2** For the purpose of determining the characteristics of electrical insulating materials particularly insulating liquids, many test methods have to be evolved and the present standard covers the method of test for specific resistance of electrical insulating liquids.

**0.3** In preparing this standard, assistance has been derived from ASTM Designation D 1169-64 'Standard method of test for specific resistance (resistivity) of electrical insulating liquids', issued by the American Society for Testing and Materials.

**0.4** In reporting the result of a test made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS:2-1960\*.

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### 1. SCOPE

**1.1** This standard prescribes the method for the determination of specific resistance (resistivity) applied to new electrical insulating liquids, as well as to liquids in service, or subsequent to service, in cables, transformers, circuit-breakers, and other electrical apparatus.

**1.2** This method covers a procedure for making referee tests with dc potential.

**1.3** When it is desired to make routine determinations requiring less accuracy, certain modifications to this method are permitted as described in 18 to 25.

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\*Rules for rounding off numerical values (revised).

## 2. SIGNIFICANCE

**2.1** The resistivity of a liquid is a measure of its electrical insulating properties under conditions comparable to those of the test. High resistivity reflects low content of free ions and ion-forming particles, and normally indicates a low concentration of conductive contaminants.

## 3. DEFINITION

**3.1** The *specific resistance (resistivity)* in ohm-centimetres of a liquid, is the ratio of the dc potential gradient in volts per centimetre paralleling the current flow within the specimen, to the current density in amperes per square centimetre at a given instant of time and under prescribed conditions. This is numerically equal to the resistance between opposite faces of a centimetre cube of the liquid.

## 4. GENERAL CONSIDERATIONS

**4.1** Where both the power factor and resistivity measurements are to be made consecutively on the same specimen, the power factor test shall always be made before applying the dc potential to the specimen, and the cell electrodes shall be short-circuited for one minute immediately prior to making the resistivity measurements.

**4.2** Referee tests for resistivity shall be made in an atmosphere of less than 50 percent relative humidity. For repeatable results, these tests should be made under carefully controlled atmospheric conditions.

**4.3** Aside from the adverse influence of contamination on results of the resistivity test, there are other factors that may contribute to variations in the test results as follows:

- a) The use of an instrument not having an adequate range for accurately measuring the current flowing in the circuit (*see 5* for two types of recommended instruments).
- b) When the time of electrification is not exactly the same for every test. Upon the application of voltage the current flowing through the specimen decreases asymptotically towards a limiting value. Variation in the time of electrification may result in appreciable variation in the test results.
- c) Undue length of time required for the test specimen in the cell to attain the desired test temperature. This is one of the main sources of erroneous results. For optimum results the time to attain the test temperature should not exceed 20 minutes.
- d) Fluctuations in the test voltage.



**4.4** To eliminate solid particles and water present in the oil (as a result of transportation, etc), the oil should be treated as follows:

The oil is brought approximately to 90°C, then filtered hot under vacuum (2.67 kN/m<sup>2</sup>). The filter should be of sintered glass of porosity 4.

The filtrate is cooled in a dessicator and is used immediately to measure resistivity.

**4.4.1** The oil samples drawn from equipment in service should not be treated.

## 5. INSTRUMENTATION

**5.1** In order to obtain the greatest precision when making this test, use the voltage-current method with the following instruments:

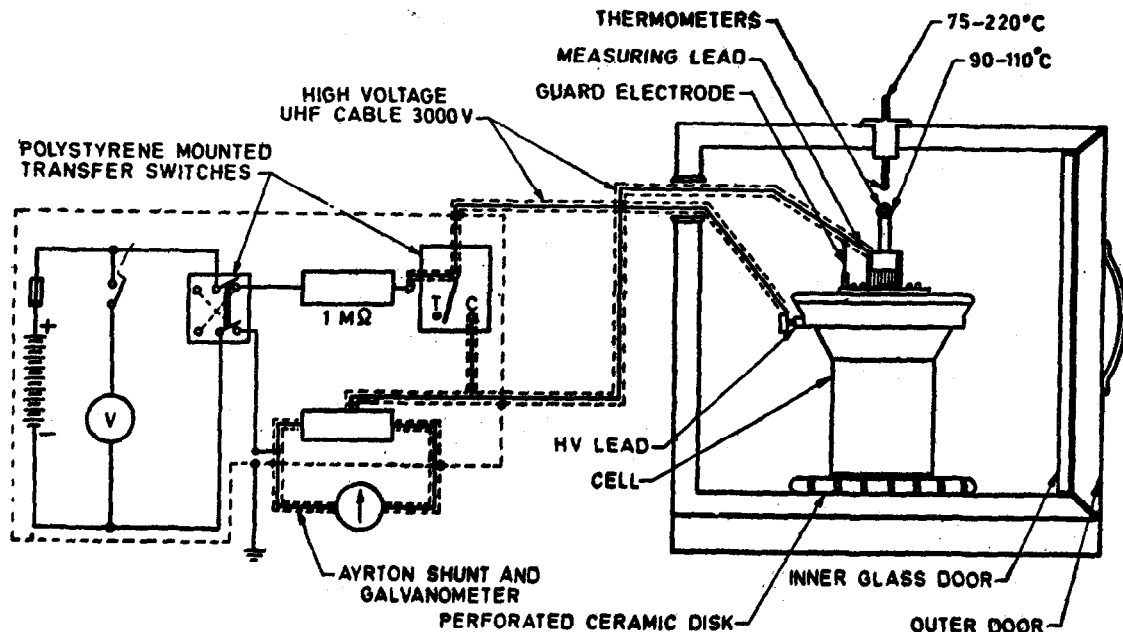
- a) *Voltmeter* — having an accuracy of 2 percent or better, operated in the upper one-third of its scale range for measuring the voltage supply.
- b) *Current-Measuring Device* — Any type of instrument having adequate sensitivity and precision and with a suitable range for measurement of a wide spread of currents encountered when making this test on new or used liquids will be satisfactory. For currents greater than 10<sup>-9</sup> A and Ayrton shunt and galvanometer having a sensitivity of 50 pA (50 × 10<sup>-12</sup> A) per division has been found convenient and satisfactory. The galvanometer deflection shall be not less than 20 divisions for the applicable Ayrton shunt ratio. For currents less than 10<sup>-9</sup> A, an electronic picoammeter has been found suitable. In using this instrument, the multiplier selected shall be such as to give at least one-half full-scale deflection on the indicating instrument.
- c) *Time-Measuring Device* — accurate to 0.5 second, for measuring the time of electrification.
- d) *Electric Cells* — connected in series are recommended for the steady voltage source.

## 6. TEST CIRCUIT

**6.1** A schematic diagram of the test circuit is shown in Fig. 1.

**6.2** The circuitry shall be so constructed that leakage is minimal. To this end the transfer switches shall be mounted on polystyrene insulation of sufficient thickness to minimize possible leakage. All soldered connections shall be made with low-thermal-emf solder using a soldering flux of resin and alcohol.

NOTE — The use of ordinary solder and flux may result in spurious thermal emf's which will cause erroneous indications.



NOTE 1 — For measurements of current less than  $13^{-9}$  A, replace galvanometer and shunt with picoammeter.

NOTE 2 — With the S.P.D.T. switch on C terminal the galvanometer may be calibrated while the electrodes of the test cell are short-circuited.

FIG. 1 CIRCUIT DIAGRAM AND CONNECTIONS WITH COMPLETE SHIELDING FOR MEASURING SPECIFIC RESISTANCE (RESISTIVITY) OF ELECTRICAL INSULATING LIQUIDS

**6.3** The test circuit shall be completely shielded. Connections to the current-measuring instrument shall be made with shielded leads. Suitable high voltage shielded leads are recommended for connecting the high voltage electrode and measuring electrode of the test cell to the test circuit.

## 7. GALVANOMETER CALIBRATION AND SENSITIVITY

**7.1** When a dc galvanometer is used to measure the current, it shall first be calibrated to ensure that it is properly balanced, that is, that the deflections on either side of zero are equal when the galvanometer is energized with 'direct' and 'reverse' polarities of the test potential.

**NOTE**—Throughout this test method the terms 'direct polarity' and 'reverse polarity' are used to indicate when the positive and negative potential leads respectively are connected to the outer electrode of the test cell.

**7.2** The galvanometer sensitivity  $G_s$ , in amperes per division, is used in computing the resistivity and is derived from the following equation:

$$G_s = \frac{E}{R} \times \frac{S}{D}$$

where

$E$  = test voltage in volts,

$R$  = calibrating resistor in ohms,

$S$  = shunt multiplying factor (ratio of galvanometer current to shunt current), and

$D$  = galvanometer deflection in divisions.

## 8. TEST CELLS

**8.1** The design of test cells that conform to the general requirements given in Appendix A are considered suitable for use in making these tests.

**8.2** Three types of guarded electrode test cells that conform to these requirements and found suitable for measuring the resistivity of insulating liquids are shown in Fig. 2, 3, and 4. In addition, a two-electrode cell suitable for making routine tests is shown in Fig. 5. These figures and a brief description of each cell is given in Appendix A.

**8.3** Because the configuration of the electrodes of these test cells is such that their effective area and the distance between them are difficult to measure, each test cell constant  $K$ , may be derived from the following equation:

$$K = 3.6 \pi C = 11.30$$

where

$K$  = test cell constant in centimetres, and

$C$  = capacitance, in picofarads of the electrode system with air as the dielectric.

## 9. TEST CHAMBER

**9.1** When the tests are to be made above room temperature but below 300°C, a forced-draft, thermostatically controlled oven shall be used as the test chamber. For tests at room temperature, the unenergized oven may be conveniently used as the test chamber.

**9.2** The test chamber shall be provided with an opening in the wall through which two lengths of suitable high voltage shielded cable will pass to make electrical connection from the measuring equipment and voltage source, respectively, to the test cell. A perforated ceramic plate or disk shall be used to insulate the test cell from the metal flooring of the oven if the flooring is not insulated from the oven.

**9.3** A cross-section view of the test chamber with a three-electrode test cell in place and with test cables connected is shown in Fig. 1.

## 10. TEST TEMPERATURE

**10.1** The temperature at which a referee test is made shall be mutually agreed upon between the purchaser and the manufacturer. Resistivity measurements are made at many different temperature. For acceptance tests, it is generally made at a temperature of 90°C, while for routine testing, it is usually made at room temperature or 90°C. In some research investigations, tests may be made at considerably higher temperature, while in other cases, particularly for tests on cable oils in service, tests may be made over a range of temperatures.

## 11. TEST VOLTAGE

**11.1** The average electrical stress to which the specimen is subjected shall be not less than 200 V/mm nor more than 1 200 V/mm. The upper limit has been set with the purpose of avoiding possible ionization if higher stresses were permitted. It is recommended that a supply voltage not materially in excess of 500 V be used. For acceptance testing, the stress and time of electrification should be mutually agreed upon by the purchaser and the manufacturer. The time of electrification in general usage is one minute.

## 12. SAMPLING

**12.1** Oils and askarels for use in this test shall be sampled in accordance with Indian Standard method of sampling for liquid dielectrics (*under preparation*). Samples for testing should preferably be obtained through a closed system. If exposed to atmospheric conditions, the sample shall be taken when the relative humidity is 50 percent or less. Some liquids, in certain applications, require special handling and processes in the sampling, and these will be found in the governing procedures. Such procedures should be consulted before samples are taken.

**NOTE** — Until the standard under preparation is published, the matter shall be subject to agreement between the concerned parties.

**12.2** The quantity of the sample taken for this test shall be sufficient for at least three separate resistivity determinations.

### **13. CONDITIONING**

**13.1** The sample shall be stored in its original sealed container and shall be shielded from light. Some liquids, such as oils of petroleum origin, undergo changes when exposed to sunlight. The sealed container shall be allowed to stand undisturbed in the room in which the test is to be made for a sufficient period of time to permit the sample to attain room temperature before it is opened.

### **14. STORING TEST CELL**

**14.1** The test cell, when not in use, shall be cleaned and dried in accordance with 15 and allowed to remain in a dust-free cabinet until it is to be used, at which time it shall be cleaned again in accordance with 15.

### **15. CLEANING TEST CELL**

**15.1** The cleanliness of the test cell is of paramount importance when making resistivity measurements because of the inherent susceptibility of most insulating liquids to contaminating influences of the most minute nature. For this reason, the cell shall be cleaned and dried immediately prior to making the test, and it is essential that the procedures and precautions outlined in 15.2 to 15.5 shall be strictly observed.

**15.2** Dismantle the cell completely and wash all the component parts thoroughly with a technical grade of either petroleum ether, hexane or petroleum spirit of a boiling point lower than 90°C. Wash the component parts with a mild abrasive soap or detergent. Take care not to lay the electrodes on any surface. Rinse all parts thoroughly with hot tap water, then with cold tap water, followed by several rinsings with distilled water. Take extreme care during the washing and rinsing of the test cell shown in Fig. 2 (see P 16) to prevent any moisture from entering the thermometer well in the inner electrode. As a precaution against this eventuality, use a suitable stopper to plug this opening prior to starting the cleaning operation.

**15.3** After the surfaces of the electrodes and guard have been washed, take care not to touch these surfaces during the rinsing or any other subsequent operation.

**15.4** Place the component parts of the test cell in an oven maintained at 110°C for a period of not less than 60 minutes. Do not dry test cells made of monel at this elevated temperature for more than 90 minutes as oxidation will take place, causing erroneous results. Take care to place the component parts of the cell on a clean surface of the oven.

**15.5** At the end of the drying period, assemble the cell in the oven, using clean cotton gloves to protect the hands. Observe the precaution given in 15.3.

**15.6** Quickly transfer the assembled test cell to the test chamber maintained at a temperature of 5°C above the desired test temperature and allow the cell to attain temperature equilibrium.

## **SECTION I PROCEDURE FOR MAKING REFEREE TESTS**

### **16. PREPARATION OF SPECIMEN AND FILLING TEST CELL**

**16.1** Use only a three-terminal cell for these tests.

**16.2** When insulating liquids are heated to elevated temperatures, some of their characteristics undergo a change with time, and the change, even though of the minutest nature, may be reflected in the resistivity results. It is, therefore, desirable that the elapsed time necessary for the test specimen to attain temperature equilibrium with the test cell be held to a minimum. For optimum procedure, this time should not exceed 20 minutes. It is essential therefore that the procedure outlined in 16.4 to 16.7 be closely followed.

**16.3** When the resistivity test is to be made subsequent to the power factor test, it follows that the precautions to be observed in preparation of the specimen and filling the test cell have already been met. In the event, however, that the resistivity test is to be made without making the power factor test, the procedure for preparation of the specimen and filling the test cell shall be as outlined in 16.4 to 16.7.

**16.4** In order that representative test specimens may be obtained, gently tilt or invert the sample container and swirl the fluid several times. Immediately after mixing the sample, pour a quantity of fluid sufficient for two fillings of the test cell into a chemically clean, dry beaker and heat on a hot plate to a temperature 2 deg below the desired test temperature. During the heating period, stir the fluid frequently.

**16.5** Remove the cell from the test oven, lift out the inner electrode, but do not rest it on any surface, and fill the cell with a portion of the heated sample. Replace the beaker with the remainder of the heated sample on the hot plate. Insert the inner electrode and rinse the electrodes by twice raising and lowering the inner electrode. Remove the inner electrode and hold it suspended in air; then decant the rinsing fluid and immediately fill the cell with the remainder of the heated sample. Replace the inner electrode.

**16.6** Insert a mercury thermometer (*see note*), graduated in 0.25°C increments, in the thermometer well provided in the inner electrode.

Immediately return the filled cell to the test chamber (adjusted to a temperature of 5°C above the desired test temperature) and make the necessary electrical connections to the cell.

**NOTE — Caution** — A spring-loaded thermocouple may be used for measuring the temperature of the inner electrode, but extreme caution shall be exercised that these wires do not come in contact with the voltage supply lead and do not pick up stray emf's.

**16.7** Perform the operations described in **16.5** and **16.6** as rapidly as possible.

**NOTE** — After much experimenting, the above technique has been evolved to give the most reproducible results for tests at 90°C. Little experience has been obtained from tests at higher temperatures. However, individual laboratories engaged in work at temperatures above 90°C have probably developed their own technique.

## 17. PROCEDURE

**17.1** Make the resistivity measurements while the temperature of the inner electrode is within  $\pm 0.5^\circ\text{C}$  of the desired test temperature. If a power factor test has been made on the test specimen, short-circuit the cell electrodes for one minute, then start the resistivity measurements immediately thereafter.

**17.2** In making the initial measurement, apply 'direct polarity' of the potential to the specimen and at the end of one minute of electrification, record the current and voltage measurements. Short-circuit the test cell electrodes for a period of 5 minutes. Calculate the resistivity (see **26**).

**17.3** At the end of the 5-minute period, remove the short-circuit from the electrodes, then apply 'reverse polarity' of the potential to the test specimen. At the end of one minute record the current and voltage measurements and calculate the resistivity. Average the resistivity values obtained from the 'direct' and 'reverse' polarity measurements.

**17.4** Pour off the liquid in the test cell and without rinsing again, fill the test cell with a second specimen from the sample and take another set of measurements as outlined in **17.2** and **17.3**.

**17.5** If the difference in the resistivity values of the two specimens is within 20 percent of the higher of the two values, no further tests are required and the average of the two specimens shall be reported as the resistivity of the sample. If the difference in the values of the two specimens is not within 20 percent, test a third specimen. If the difference in the values between any two of the three specimens is not within 20 percent, clean the test cell and test specimens from another sample until the difference in the resistivity of two specimens is within 20 percent.

**17.6** When the power factor results on specimens from a sample are not within the limits specified in **12** of IS:6262-1971\*, do not report the results of resistivity measurements on these specimens (if made) and repeat the test when resamples are obtained.

\*Method of test for power factor and dielectric constant of electrical insulating liquids.

## SECTION 2 PERMISSIBLE MODIFICATIONS WHEN MAKING ROUTINE TESTS

### 18. GENERAL

**18.1** When it is desired to get an approximation of the resistivity of a sample or to make tests on a group of samples of the *same* type of insulating fluid to ascertain whether the resistivity is greater or less than some specified value, certain modifications to 16 and 17 are permitted as outlined in the following clauses.

### 19. TEST CELL

**19.1** Any test cell conforming to the requirements given in Appendix A may be used. For routine tests, however, the requirements for a guard electrode may be waived provided that the two-electrode cell used is of adequate capacitance and with sufficient ratio of surface area to specimen thickness to provide proper operation of the measuring equipment. One such cell is shown in Fig. 5 (*see* P 18).

### 20. TEST CHAMBER

**20.1** An oil bath having uniform temperature distribution and provided with adequate temperature regulation may be used for routine tests, provided that, when the test cell is immersed in the bath, the temperature difference in the test cell between any part of the inner electrode and the outer electrode does not exceed 2°C. A less satisfactory method is the use of a hot plate, but variations in temperature throughout the cell may lead to questionable results. In general, the use of a forced-draft air test chamber is preferable.

### 21. TEST TEMPERATURE

**21.1** Resistivity measurements may be made when the test specimen is within  $\pm 2.0^\circ\text{C}$  of the desired temperature.

### 22. CLEANING TEST CELL

**22.1** Since some two-electrode cells cannot be dismantled, the cleaning procedure given in 15 cannot always be followed. Where this applies, it is imperative that each laboratory evolves a good cleaning procedure for the cell used so that repeatable results may be obtained. Only solvents mentioned in 15.2 as being satisfactory shall be used as cleaning agents.

**22.2** When a number of samples of the *same* type of fluid are to be tested consecutively, the same test cell may be used without cleaning, provided that the resistivity of the sample previously tested was greater than the specified value. If the resistivity of the last sample tested was less than the specified value, the test cell shall be cleaned before using for further tests.



## 23. PROCEDURE

**23.1** Because of the difference in construction of the various types of test cells that may be used for routine tests, no detailed procedure for preparation of the specimen and filling of the test cell is given. Due regard should be given to the precautions outlined in 16.

**23.2** Before filling, always rinse the test cell with a portion of the sample to be tested.

## 24. ELECTRICAL CONNECTION

**24.1** When making electrical connection to a two-electrode cell, the shield on the lead usually connected to the guard electrode (*see* Fig. 1 on P 6) shall be securely clipped to the PTFE (polytetrafluoro ethylene) insulation in order to prevent contact with any surface.

## 25. NUMBER OF TESTS

**25.1** Only a single test specimen need be tested in measuring the resistivity of a sample.

## 26. CALCULATIONS

**26.1** Calculate the resistivity of a specimen  $\rho$  in ohm-centimetres  $\times 10^{12}$  by using one of the following equations, depending on whether the galvanometer or picoammeter was connected in the test circuit:

a ) Using the galvanometer for current measurement:

$$\rho = \frac{E \times K}{D \times G_s}$$

b ) Using the picoammeter for current measurement:

$$\rho = \frac{E \times K}{I}$$

where

$E$  = test voltage in volts,

$K$  = cell constant in centimetres,

$D$  = galvanometer deflection in divisions,

$G_s$  = galvanometer sensitivity in amperes  $\times 10^{-12}$  per division,  
and

$I$  = current in amperes  $\times 10^{-12}$ .

## 27. REPORT

- 27.1 Use the following table as a guide in reporting the values of resistivity:

$\rho$ , ohm-cm $\times 10^{12}$	Report Value to
500 or greater.....	Nearest 50
100 or greater, but less than 500.....	Nearest 10
10 or greater, but less than 100.....	Nearest integer
Less than 10.....	Two significant figures

- 27.2 The report shall include the following:

- Type of cell used,
- Method of measurement,
- Average voltage gradient in the sample while under test in V/mm,
- Temperature of the sample while under test,
- Temperature and humidity of the room during test, and
- Specific resistance ( resistivity ) of the sample.

## APPENDIX A

( Clauses 8.1, 8.2 and 19.1 )

### CELLS USED FOR MEASURING SPECIFIC RESISTANCE ( RESISTIVITY ) OF ELECTRICAL INSULATING LIQUIDS

#### A-1. DESIGN OF CELL

**A-1.1** A cell for the purpose of measuring the specific resistance, (resistivity) of electrical insulating liquids should meet the following general requirements.

**A-1.1.1** The design of the cell shall be such as to facilitate easy and thorough cleaning of its component parts, permit the use of the cell in a suitable temperature bath, and provide means for measuring the temperature of the liquid under test.

**A-1.1.2** The materials used in constructing the cell shall be non-porous and capable of satisfactorily withstanding the temperature to which the cell will be subjected under test. The alignment of the electrodes shall not be influenced by this temperature nor by the operation of filling the cell with the test liquid.

**A-1.1.3** The electrodes or their surfaces shall be made of a metal capable of resisting attack by mild acids, such as are found in oils of petroleum origin, particularly after prolonged exposure at elevated temperatures.

Metals that have been found satisfactory from this standpoint are gold, nickel, monel, platinum, and stainless steel. Plated surfaces that may be satisfactory for short periods of time for testing liquids having low acidity are gold, platinum, nickel, chromium over nickel, or rhodium.

**A-1.1.4** When most accurate resistivity determinations are to be made, a guard electrode shall be provided which adequately shields the measuring electrode. A shielded wire or coaxial cable shall be used to connect the guard and measuring electrodes, either directly or by a plug to the measuring circuit.

**A-1.1.5** The solid insulation used to support the guard electrode relative to the measuring electrode shall not extend into the portion of the sample being tested.

**A-1.1.6** The insulating materials used in constructing the cell shall not absorb or be adversely affected by the test liquids or cleaning solvents. The insulation resistance of these insulating materials shall necessarily be high, particularly that between the guard and the measuring electrodes. Insulating materials that have proved satisfactory are borosilicate glass, quartz, steatite, and PTFE (polytetrafluoro ethylene). Thermoplastic materials, such as hard rubber and polystyrene, although having good electrical properties, are not suitable as they soften below 130°C. Insulating materials of the moulded mica-dust type have been found to absorb solvents and, therefore, are not considered as satisfactory in the measurement of liquids having high resistivity values.

**A-1.1.7** In designing the cell, the distance across the surface of the test specimen and across the solid insulating material between the guard and the measuring electrode shall be great enough to withstand adequately the test potential used. Leakage across these paths has been found to produce erroneous results.

**A-1.1.8** The surface area of the measuring electrode and the gap spacing between the measuring electrode and the high voltage electrode shall be such that the ratio of surface area to the thickness of the test specimen shall be large enough to provide sufficient current for adequate operation of the measuring equipment. It is required, however, that the precision of the measurements meet the intended accuracy of this method.

## **A-2. RECOMMENDED TEST CELLS**

**A-2.1** Four cells that have been found suitable for measuring the resistivity of electrical insulating materials are shown in Fig. 2, 3, 4 and 5. The following is a description of each:

- a) *Figure 2* — The cell shown in Fig. 2 is a three-terminal cell intended for making referee tests where absolute resistivity determinations are to be made. It is made of monel, its volume is 185 ml, its capacitance with air as the dielectric is approximately 75 pf, and it is suitable for use at voltages up to 5 kV and temperatures up to 150°C.

- b) *Figure 3*—The cell shown in Fig. 3 is also a three-terminal cell intended for making research investigations on small volumes of liquid at temperatures up to  $500^{\circ}\text{C}$ . It is made of monel, its volume is 40 ml, its capacitance with air as the dielectric is approximately 35 pf, and it is suitable for use at voltages up to 5 kV.
- c) *Figure 4*—The cell shown in Fig. 4 is a three-terminal cell also intended for making referee tests and research investigations on small volumes of liquid at temperatures up to  $150^{\circ}\text{C}$ . It is made of stainless steel, its volume is 45 ml, and it is suitable for use at voltages up to 3 kV.
- d) *Figure 5*—The cell shown in Fig. 5 is a two-electrode cell intended solely for making routine tests where it is desired to ascertain whether a sample is greater or less than some specified value. The concentric cylinders are of nickel-plated brass which are mounted on a PTFE (polytetrafluoro ethylene) base and contained in an 800-ml borosilicate glass beaker. The volume of oil required when using this cell is 500 ml. The cell is suitable for use at voltages up to 5kV and temperatures up to  $150^{\circ}\text{C}$ .

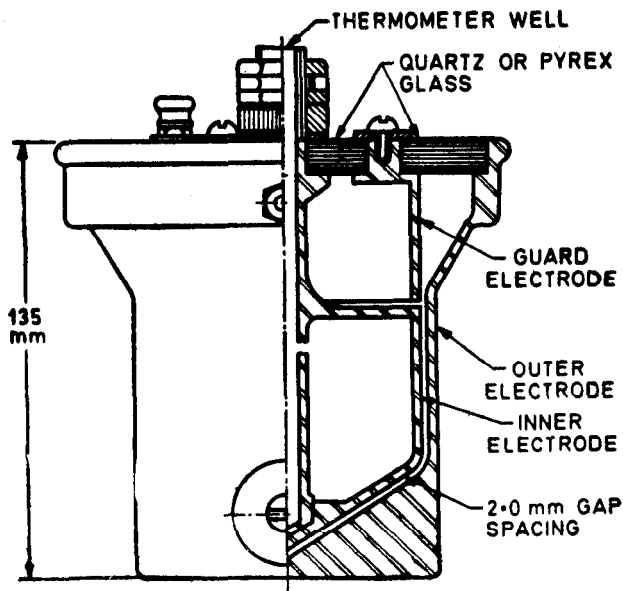


FIG. 2 CELL FOR REFEREE TESTS

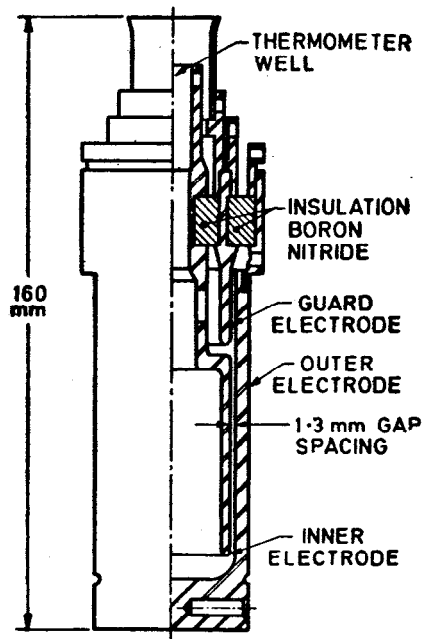


FIG. 3 CELL FOR RESEARCH INVESTIGATION

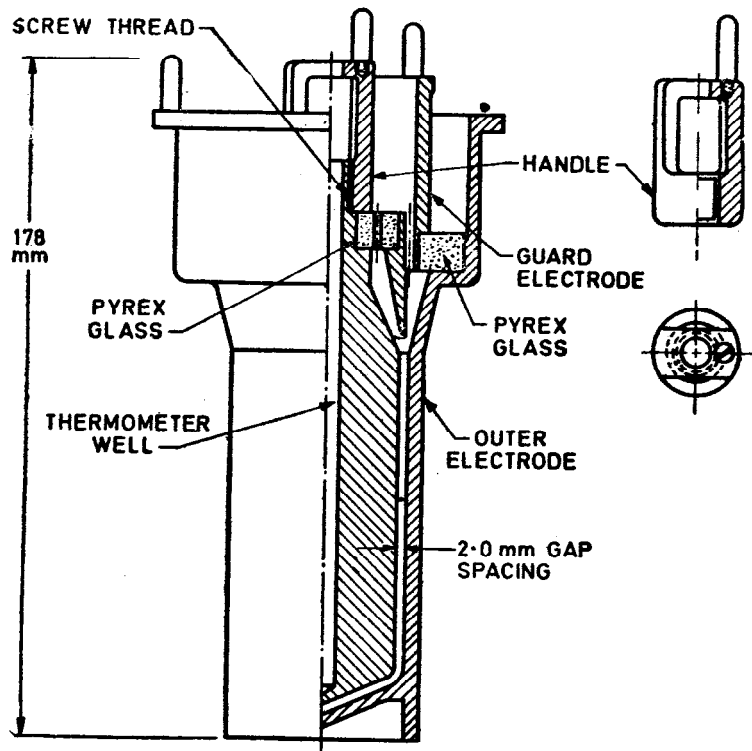


FIG. 4 SMALL CAPACITY CELL FOR REFEREE TESTS AND RESEARCH INVESTIGATIONS

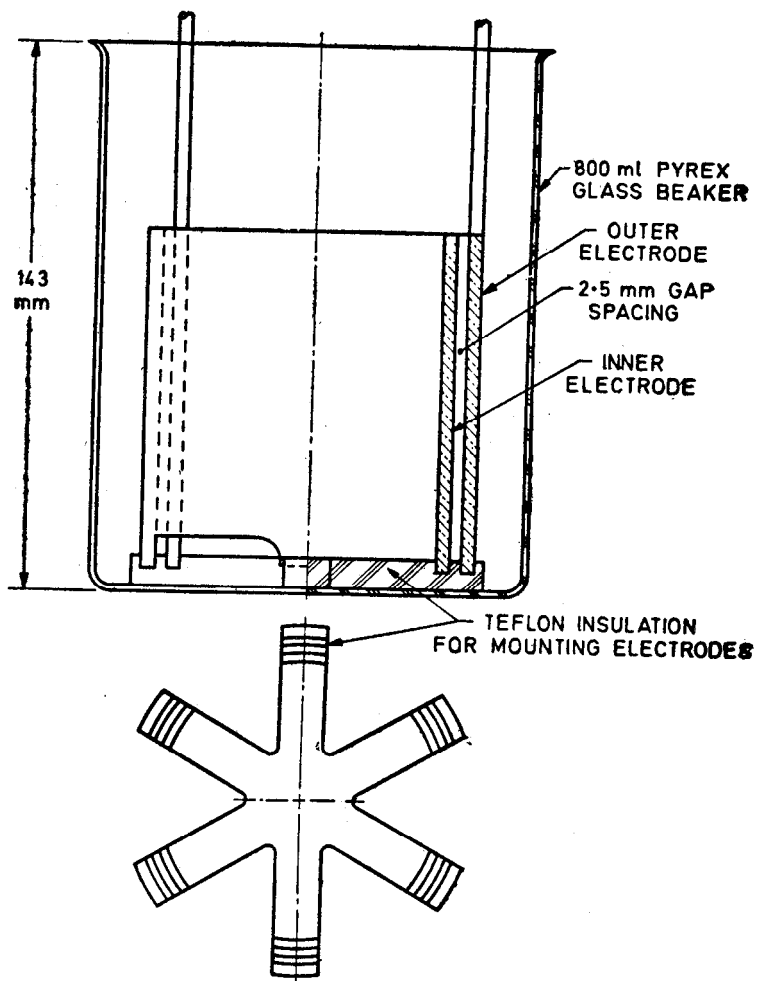


FIG. 5 TWO ELECTRODE CELL FOR ROUTINE TESTS

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TO

IS:6103-1971    METHOD OF TEST FOR SPECIFIC  
RESISTANCE (RESISTIVITY) OF ELECTRICAL  
INSULATING LIQUIDS

(Page 11, clauses 17.2 and 17.3) - Substitute the following for the existing two clauses:

"17.2 In making the measurement, apply only 'direct polarity' of the potential to the specimen and at the end of 1 min of electrification record the current and voltage measurements. Calculate the resistivity (see Note).

Note - The reverse polarity reading need not be recorded as widely differing direct and reverse polarity readings are obtained for most of the new insulating oils. The final resistivity value can be reported based on the direct polarity reading only."

(Page 11, clause 17.4, line 3) - Delete the words 'and 17.3' and renumber the clauses '17.4, 17.5 and 17.6' as '17.3, 17.4 and 17.5' respectively.

(ETDC 64)